Look to the Hardwoods!

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Because of the widespread interest in hardwood management now being felt in the Northeast, it was decided to issue this section as a separate so that it could be made available to more people than might receive the Annual Report.

Look to the Hardwoods!

An Opportunity ... & A Proposed Research Program For Improving The Neglected Hardwood Resource

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Look to the Hardwoods!

THE NORTHEAST is hardwood country. To be sure, central and northern Maine and the higher elevations of the Green Mountains, White Mountains, and Adirondacks have their spruce-fir; cool, moist sites throughout the region typically support some hemlock; and white pine--the original foundation of the lumber industry in North America--is widely represented by scattered stands and by individual trees intermixed with other species. But in broad panorama, the forests of the Northeast take their predominant tone and character from the hardwoods. So it was in the days of the Pilgrims; and so it is today on the lands that remain in woods.

In the interim, land-clearing and settlement reached its peak. Then, particularly in New England, starting in the middle 1800's, came the era of land abandonment, followed by the growth of "old-field" pine, the cutting of these pine stands, and reversion of most of the temporary pine lands back to hardwoods.

Northern hardwoods, characterized by beech-birch-maple, plus varying proportions of hemlock and white pine, are or were predominant from northern Pennsylvania through most of New York and northern New England, exclusive of the spruce-fir areas. Oak types, in which chestnut formerly was an important component, predominate through central and southern New England, the Hudson and Mohawk valleys and south of Lake Ontario in New York, and from central Pennsylvania southward through Maryland and West Virginia. This, of course, is painting with a very broad brush. Various subtypes and transition types would have to be recognized in a more detailed description.

A BRIEF LOOK AT THE PAST

The virgin forests no doubt were magnificent and impressive to behold. However, not all of the trees by any means were quality specimens; in fact, a considerable proportion of them were overmature and defective. But there was, nevertheless, more than enough good and high-grade material to satisfy local needs and the demands of foreign trade during the period of settlement. During this period, timber products were largely a byproduct of land-clearing for agriculture; a lumber industry as such scarcely existed at that time.

The rise of the lumber industry in New England dates from about 1820, when agricultural development reached its maximum. The next few decades witnessed a rapid expansion of textile and other industries in the towns, drawing people from the farms. Another factor drawing people from the farms was increasing migration to the Midwest. As land-clearing for agriculture waned, lumbering as an industry grew. The lumbering of this era, up to about 1880, was largely a creaming or high-grading operation: only the larger, higher-quality trees of white pine, spruce, and a few preferred hardwood species were cut. Although there was no planned management for future production, the land was left in forest--somewhat deteriorated in quality but by no means devastated.

About 1880 marks the beginning of the period of extraordinarily heavy cutting in New England and the Northeast generally. Increasing demand for lumber, and increasing scarcity of high-quality sawtimber doubtless were factors in the changing practices; but the advent of the portable steam-powered sawmill seems to have been the turning point. With the moving of the mill to the woods, there grew up the custom of lump-sum sales of timber. The sawmiller, having paid for everything, and having his mill on the ground, took every stick that offered a remote chance of paying its way.

The result was not clear-cutting in the strict sense of the word, because all culls and the largely unmerchantable species like beech and red maple were left standing. But the woods were usually left in a sorry state, and fire not uncommonly followed in the slash. The widespread practice of such cutting ushered in the so-called hardwood problem that has been with us ever since.

PRESENT-DAY HARDWOOD FORESTS

In the twelve Northeastern States, according to the Timber Resource Review made by the U. S. Forest Service, 57 percent of the land is classified as commercial forest land, and 42 percent (of all land), or 53.5 million acres, is occupied by hardwood forest cover types. Distribution is of course not uniform; the hardwoods occupy a considerably larger proportion of all forest land in the Middle Atlantic States than in New England.

Northern Hardwoods In Better Condition Than The Oak Forests

The northern hardwood type, sugar maple-beech-yellow birch, occupies 21.3 million acres, almost equally divided between New England and the Middle Atlantic States. Oak-hickory occupies 21.8 million acres; with the oak-pine and oak-gum types added, the total for types dominated or strongly flavored by oaks is more than 25 million acres. Of this, close to 22 million acres are in the Middle Atlantic States. All hardwood acreage not included in the above figures is in aspen-birch or ash-elm-maple types; it totals about 7 million acres.

By and large, the oak forests are in worse condition than the northern hardwoods. Oak types tend to occupy drier sites, and consequently have suffered more damage from fire. Moreover, the oak types are found near the coast, in valleys such as the Mohawk and the Hudson, and often on less rugged terrain where industry and high populations have developed. Intensity of utilization therefore has been greater. Second- and even third-growth stands have been cut in many places. Charcoal wood, fuelwood, and mine-prop demands have resulted in extensive clear-cutting and the cutting of young stands. Removal of the chestnut from these stands by the blight was an additional blow from which many stands have not yet fully recovered. Also, in the New England area, oak forests have suffered repeated injury from defoliation by the gypsy moth.

As a result of their history of heavy but haphazard cutting, plus the cumulative effects of insect, disease, and fire damage, the oak forests--especially near centers of population--are now largely coppice growth, of poor form, and prevalently butt-rotted through fire scars and infection from the old stumps. Site quality very commonly has under-

gone deterioration from past fires. The scrub oak types found through the Poconos and westward in Pennsylvania are an extreme manifestation of site and stand deterioration, due primarily in this instance to repeated fires.

Fortunately, not all forests in the oak types are in such sad shape. Second-growth stands in the rougher sections of Pennsylvania, Maryland, and West Virginia have not generally been subjected to such intensive use; and though little silviculture has been applied to them, these stands are in many places in fairly good condition.

(The condition of the coastal oak-pine forests varies from fair to very poor. But despite the generally poor form, slow growth, and defects of the oaks and other hardwoods, many of these stands have a fairly good productive potential in the pines. The pines tend to be better adapted to the sites, and most of the type apparently can best be managed for pine. So, although these forests are mentioned here as part of the complex of types having a strong oak component, they are not, strictly speaking, a part of the hardwood-management problem, and would not be included in a program of hardwood-management research.)

The northern hardwood forests typically occupy moister sites than the oaks. They are distributed mostly in the mountainous sections, and in general they are more remote from centers of population. They have been cut over, but have not generally been subjected to the charcoal-wood, fuelwood, mine-prop type of utilization and to the repeated fires that have wrought havoc in many oak stands. The high-grading type of cutting that prevailed until about 80 years ago left many smaller trees and advance reproduction that soon filled in the holes where trees had been removed. Even the first "clear" cuttings after 1880 were not entirely devastating, unless followed by fire.

Because there usually was advance reproduction to develop after cutting, and secondly because stumps of the large old trees did not produce many sprouts, the second-growth northern hardwood stands typically were of fair quality. Overall quality was of course adversely affected by the culls and trees of low-value or of non-commercial species left by the loggers, but the second growth almost always included many seedling stems with a quality potential.

The real "hardwood problem" in the northern hardwood type develops when second growth is clear-cut at a compara-

tively immature age. The resultant third growth is of much lower quality because, with little advance reproduction established, and with stumps still young enough to sprout vigorously, the regeneration is largely of sprout origin.

Where fire has occurred, as has often happened in the slashings---even though the type is less fire-prone than the oak areas---the adverse effects of clear-cutting are compounded. Any white pine or other coniferous components are destroyed, the hardwood overstory is killed, to be followed by sprout and root-sucker growth. Weed species such as pin cherry, birch, and aspen seed into the bare spots. This sequence---clear cutting followed by fire---has given rise to most of the understocked low-quality sprout stands now found in the northern hardwood type.

Where there has been a succession of fires, the type tends to go over to aspen-birch. This is a weed type of little or no value when the birch element is mostly gray birch. Where paper birch is well represented, and if the site will support good growth of that species, the aspen-birch fire type may develop stands of considerable commercial value. There are 4.8 million acres of aspen-birch in the Northeast, but only a small part of this area supports stands of paper birch.

Poletimber Stands Predominate

Density of stocking and proportion of forest area in different stand-size classes are criteria of forest quality. However, the available figures are for all forest land, without breakdown by types. About 10 percent of the forest area in New England, and 15 percent in the Middle Atlantic States, is less than 40 percent stocked. In this respect the forests of the Northeast are in general better than those of other eastern regions.

As regards stand-size classes, 19 percent of the forest area in New England, and 24 percent in the Middle Atlantic Region, are in seedling-and-sapling stands or are nonstocked---again somewhat smaller percentages than in other eastern regions. Approximately one-third of the forest area in New England is classed as sawtimber, and about 36 percent in the Middle Atlantic States. The rest---48 percent and 40 percent respectively for the two regions--is poletimber.

The comparatively high proportion of poletimber stands is significant. It means (1) low yields of forest products in the immediate future, but (2) large areas of growing forest which can contribute to greatly increased yields a few decades hence.

The picture conveyed by the above figures is neither markedly bright nor markedly gloomy. True, there are understocked and depleted areas to give us concern, and there is a lot of poletimber too young for harvest cuts. But with poletimber or sawtimber growing stock on close to 80 percent of the forest land, the task of bringing these lands into a state of high productivity certainly is an attainable objective under reasonably intensive silviculture. The Northeast has, in this growing stock, an excellent raw-material potential for supporting forest industries. The job that faces research and management is to bring that state of high productivity to realization.

Scarcity Amid Abundance

With 53.5 million acres of hardwood forest in the Northeast, more than a third of which is classed as sawtimber stands, good hardwood timber is nevertheless a scarce commodity today. Yet for years people have talked of the "hardwood problem" as being largely one of getting rid of the hardwoods and replacing them with white pine, spruce, or other conifers. So we are in the anomalous position of deploring the scarcity of good high-utility hardwoods while surrounded by a plethora of hardwoods that are regarded as of little value or worthless--even though they are composed at least in part of the same species as those in demand.

This situation has developed from a century or more of cutting with little or no planned management for future production. Repeated high-grading of the better trees, leaving the culls and unmerchantable species to occupy space, has greatly reduced the proportions of such valuable intolerant species as black cherry, white ash, paper birch, and yellow-poplar. The tolerant species and those least in demand have increased proportionately, notably beech, which is both tolerant and in low demand. But the trees that are left, of whatever species, are predominantly low grade or culls. Where there has been fire or cutting of young second-growth trees, sprawling sprout clumps have taken over and,

in the absence of suitable cultural measures, promise little except low-grade material.

Hardwood Cut Is Much Less Than Growth

Although the cut of hardwoods in the Northeast is substantial--1.67 billion board feet in 1952--the cut is less than half the net annual growth. This compares with a softwood cut of 1.89 billion feet, which considerably exceeds growth but falls far short of local softwood requirements.

The very favorable ratio of hardwood cut to growth would seem to indicate that we are growing more hardwoods than we need. This undoubtedly is true for the low-quality trees that make up the bulk of the stands, which fact emphasizes again the scarcity amid abundance. For in the face of this favorable growth balance, such quality materials as tough ash, oak for bending and tight cooperage, high-grade sugar maple, and yellow birch for face veneer are scarce or almost nonexistent. With some other items, such as high-grade black cherry, scarcities are perhaps not quite so acute; yet the supply is short enough that phenomenal prices are paid for logs that meet certain specifications.

The hardwood market in general has higher quality demands than the softwood market. Except for the current upswing in use of hardwoods for pulp, there have been only limited outlets for the lower grade materials, and these at prices that offered little incentive to the producer. Moreover, extraction and conversion costs are higher for hardwoods than for softwoods. These are contributing reasons for the relatively low cut in relation to growth in our present-day low-grade hardwood stands.

A CHANGING ATTITUDE TOWARD THE HARDWOODS

General condemnation of the low-grade hardwood stands as worthless, with hopes of future returns built around conversion to conifers, has in recent years been giving way to a different point of view. True, on the sandy soils and other medium to poor hardwood sites, conversion to conifers

still appears to be the better course. But it is becoming increasingly recognized that most of the heavier soils are by nature better adapted to hardwood growth, and that on the better hardwood sites an inordinate amount of costly strong-arm work is required to establish conifers and keep them above the hardwood competition, even with the aid of modern silvicidal chemicals. Would it not be more logical and practical to work <u>with</u> rather than against Nature: devote our efforts to improving the quality of the hardwood growing stock and the production of good hardwood timber?

Increasing acceptance of the idea of devoting the better hardwood lands to sustained quality-hardwood production is crystallizing into a new attitude among both foresters and laymen that, we believe, presages a new era in northeastern forestry. Instead of deploring a hardwood problem, we are recognizing a hardwood opportunity--an opportunity to develop and get into practice silvicultural and management methods that will efficiently utilize the full natural capacity of these lands to produce forest products. The immediate tasks before us are to find out which sites or areas should be devoted to hardwoods, and how best to grow them on those areas.

Nothing in this sharpened interest in hardwoods involves any belittling or de-emphasis of white pine and other conifers. The demand for softwood timber continues to increase, and there should be no slackening in efforts to improve softwood management and expand softwood production. The new attitude only means greater recognition of the principle that each site or area is best adapted to certain kinds of trees or types of forest. Softwood sites would be given over to the culture of softwood forests, some sites might well be assigned to mixed softwood-hardwood types, and the sites best adapted to grow high-utility hardwoods would be devoted fully to their production.

The time is ripe, as it has never been before, for developing hardwood forestry.

One of the chief factors in transforming the problem of yesterday into the opportunity of today is the improved technology and expanding market for hardwood pulpwood. About a third of the wood going into pulp now is hardwood. With this market, it becomes profitable to remove much of the low-grade hardwood from stands in thinning and stand-improvement cuttings, and thereby build up a growing stock of good-quality trees. The job of putting run-down hardwood

forests under management thus becomes economically feasible from the time of the first conditioning cuts.

The favorable situation in the pulpwood field is further abetted by other technological advances--better knowledge on how to dry and use beech lumber, for example--and by the sustained high level of industrial and economic activity in the country. All this means markets for low-grade material, without which no substantial progress in improving hardwood stands is possible.

WHAT HAS BEEN DONE

To manage our hardwood forests, with their considerable number of species growing on a wide array of soil and site variations, requires both basic and practical how-to-do-it information. Although present knowledge of hardwood management is by no means a blank page, there are a great many blank lines. Observations and a limited amount of more formalized research over the past half-century have provided some pretty good general information on the site requirements, the relative tolerances, and the more important pests of the major species. We think we know some of the fundamentals of their management: which species can be grown in all-aged stands and cut by single-tree selection; which do better in even-aged stands or groups under some variant of clear cutting practices; which species should be favored on dry sites or moist sites, light soils or heavy soils, and so on. And we know that hardwoods are much more sensitive to adverse factors in field planting than are the conifers.

Questions, Questions

The blank lines on the management page show up when the forester comes face to face with specific cases and situations. For a specific combination of stand, site, accessibility, and markets, what species to favor? how favor certain ones and suppress others? how cut the stand? how obtain the desired reproduction? how much growing stock to carry? how minimize insect and disease losses? Or, considering special product requirements, on what sites and under what climates and management methods can wood of such properties as high density, toughness, or high bending strength be grown? In answering and acting upon all such questions

as these, the requisite information is incomplete, the guidelines not well established. The forest manager must, to a large extent, play by ear.

Site, for example, is a field in which very little basic research has been done in the Northeast. Good progress in soil classification and mapping of cultivated areas is being made by the Soil Conservation Service, but only a little of such work has been done in forested areas. Soil classification oriented to cropland agriculture is by itself of limited value in forest-site classification. There have been a few studies dealing with the forest-site-indicator significance of the low vegetation. The need in forestry is for site classification in which soil type, cover type, and the various physiographic factors are integrated to provide a basis for predicting growth and productivity by various tree species. Two studies of this sort have recently been done--one in Maine with reference to red spruce, and one in West Virginia with reference to oaks. These are helpful steps; much more work along somewhat the same lines should be done.

Regeneration--how to get natural reproduction of desired species or how to plant them--is a universal problem in forest management. Knowledge of site-species relationships is a prerequisite for wise choice of the species to be favored. As regards natural regeneration, foresters have a fairly good understanding of the seedbed requirements, tolerances, and competitive ability of our native hardwoods. Often a major problem in obtaining the desired reproduction is to suppress undesirable but more aggressive competitors. In part this may be accomplished by careful manipulation and timing of the harvest cuts. Failing in this, we may accomplish our purpose by weeding and release treatments. Although the basic principles are well known, much more research will be required to establish precisely how one can obtain natural regeneration of the different species in various situations.

As for planting hardwoods, it has been abundantly demonstrated that the conventional methods used for conifers generally fail. Various theories are extant as to why this is so, and as to what is required for hardwoods to succeed; but there are few successful hardwood plantings to cite as evidence. Hardwood planting is a field that is wide open for fruitful research.

Work in forest-tree improvement, or genetics, has been under way in the Northeast for about 30 years, with emphasis mainly on hybrid poplars. Since the war, a marked upsurge of interest in forest genetics has developed country-wide, centered largely upon conifers. In the Northeast, the Station has done a little preliminary work on hardwoods other than poplar--specifically on the birches, maples, and ashes. Except with the poplars, none of this work has progressed to the point where superior selections or hybrids are available for large-scale testing.

Forest-Wildlife Relationships

Wildlife in varying degrees is an important factor in forest management throughout the Northeast. Deer of course receive the most attention, both as part of the forest-land crop and as a pest that interferes with forest regeneration. In certain sections, notably northern Pennsylvania, an over-population of deer practically precludes the establishment of reproduction of black cherry, red and sugar maples, and most other native timber species except beech, thus making efficient forest management almost impossible. Rabbits, mice, and porcupines also are more or less destructive. Small planted trees of nearly all species are subject to damage by rabbits and mice, as well as by deer; rabbits and mice are particularly destructive of hardwood species. Many plantation failures have been caused mainly by wildlife depredations.

Both the Station and other agencies have maintained some fenced exclosures to demonstrate that deer and/or rabbits do in fact keep down the growth of tree seedlings, and to get a quantitative measure of the damage. Wildlife researchers have given us a pretty good understanding of the foot habits, preferred food-plant species, and nutritional requirements of the different kinds of forest wildlife, particularly for deer. But very little has been done in our region on methods for protecting trees or forests against wildlife, or on ways to minimize the damage.

NEGLECTED AREAS IN RESEARCH

With the great diversity of forest conditions found in our 12-state territory, it is but natural that some problems or aspects of problems should be neglected under the

limited research programs now under way. These may be considered briefly under the general headings of species and fields of study.

Which Species Need Study Most

In general, more silvical and silvicultural information is available for the commercially important conifers than for the hardwoods. Of the hardwoods, knowledge is somewhat more extensive for certain of the choicer species like white ash, yellow-poplar, white oak, and red oak. Less work has been done on the maples, birches, beech, hickory, basswood, and the lower-value oaks. Strange as it may be, black cherry has not been as much studied as some of the other hardwoods, despite the fact that choice logs command a higher price than those of any other northeastern species. This neglect is partly explained by the comparatively small commercial range of the species, and by the comparatively recent development of high demand in relation to supply.

The adequacy of information on the more important commercial species is of course relative; none has been wholly neglected by research workers, and none has been exhaustively studied. Much remains to be learned of the silvical characteristics of each species, and of how to translate silvical knowledge into effective silviculture and management practices. However, taking our northeastern hardwoods under today's market conditions and conditions in the woods, the following species may be named as having received comparatively little research attention, and as likely to yield good dividends from more intensive study.

- Black cherry. Major problem is how to perpetuate in it natural forest stands. Associated problems are protection against deer in seedling stages, control of seedling diseases, and how to establish the species by planting.

- Paper birch. The major problem, as with cherry, is how to perpetuate the species in natural stands. Associated problems are how to minimize post-logging decadence in partial cuttings and how to establish the species by planting. The dieback - bronze birch borer complex, though causing less concern now than a decade ago, also should be included among paper birch problems. This malady, which has marked similarities to post-logging decadence but may appear in un-

disturbed stands, and is believed to be caused by weather factors, still is somewhat of an enigma.

- Yellow-poplar. Again, major problems are perpetuation of the species, and how to plant it successfully. Inasmuch as good poplar sites usually are also very good for Japanese honeysuckle, control of this vine in some places is an important secondary problem in poplar management, and may be the determining factor in obtaining regeneration.

- Beech. In contrast to cherry, birch, and poplar, the major problem with beech is how to prevent it from becoming predominant at the expense of other more desirable species in the hardwood forest. Associated problems are how to produce higher quality material in the beech that is retained in the stands, and how to control or minimize the losses from the beech scale - nectria complex.

Two other species or groups may also be noted, since they are somewhat in the public eye. Sugar maple, which is of unique importance in parts of the Northeast as the source of maple-sugar products, is to receive attention at the Station's newly established unit at Burlington, Vermont. As a timber species, sugar maple poses less urgent problems than the species listed above. Secondly, the oaks as a group are of concern because of the oak-wilt disease and an unidentified dieback disease prevalent among red oaks in northwestern Pennsylvania and adjacent New York. Both diseases are receiving research attention. If either of these diseases should become a serious threat to our oaks, it would profoundly affect management problems and practices in the oak types.

Fields Of Study

Silviculture traditionally has drawn the major share of forestry research effort; and, as previously noted, a fairly good body of silvical and silvicultural knowledge has been built up. Much still remains to be learned, however, about the silviculture of all our commercial forest species, both softwood and hardwood.

A major need is for research to adapt the available generalized information to variations of climate, soil, site, forest cover and forest condition. The most effective application of known silviculture principles depends upon

such testing and adaptation.

Current waves of popular interest in other fields of study, worthwhile though they may be, should never be allowed to divert research efforts entirely or even largely away from silviculture. As the mainstay of forest science and practice, silviculture must remain a field of continuing investigation.

One neglected field of study, closely related to silviculture, is hardwood forest tree planting. Although a fair amount of empirical planting research has been done, the emphasis has been mainly on conifers. As noted earlier, hardwoods respond poorly to the usual methods of field planting, and have therefore been largely dropped from action programs in reforestation. Only a few sporadic attempts have been made to determine why the hardwoods fail, or what is required for them to succeed. Prior to World War II the Northeastern Station had started studies along these lines, but the project was dropped during the war and never reactivated. Now, with the upsurge of interest in hardwood forest management, the need to find out how to plant these species successfully takes on an added urgency.

Another neglected field, also closely related to silviculture, is investigation of soils and sites. The science of forest soils is a relatively new specialization in the broader field of soil science. Technicians are trained in forest soils in only a few schools, and still are scarce. Research calling for the skills of forest soil scientists is needed to develop ways and means to classify and identify the soil and site variants that are significant to tree growth and vigor, and to determine the relationships between those variants and different tree species. Better knowledge and understanding of site relationships will provide a much firmer footing for the practice of silviculture in managing our forests, and such understanding is essential to progress in solving the hardwood planting problem.

Forest tree genetics, though it has been on the scene for some 30 years, has until recently attracted little financial support, and except for the poplars, hardwood species have been almost wholly neglected. Little is known as yet of the extent of genetic variation in the important hardwoods, of the possibilities for selecting and propagating naturally superior strains, or for producing superior strains by hybridization. In fact, for sugar maple and probably some other species, problems in such facilitating

techniques as vegetative propagation must be solved before real progress can be made in the production of superior strains.

Other fields of study that have been neglected or only superficially worked include (1) how to produce wood of specific qualities such as high density or good bending properties; (2) optimum densities of stocking for various species or types on different classes of sites or in different geographic regions; (3) cost and return aspects of various silvicultural measures such as weeding, noncommercial thinning or release cutting, pruning, seedbed preparation, and the like for different species, forest types, sites, and regions; (4) control or evasion of wildlife damage; (5) silvicultural uses of herbicidal chemicals.

Finally, without pin-pointing particular fields of study, we can say that basic research as a philosophy and a method has been pretty much neglected in forestry. The approach in the past has been largely empirical, which has served us well, and will continue to characterize a substantial part of our research effort. But forestry has come of age to the point where we should dig deeper into the fundamental processes and reactions of trees and of the other life forms that affect tree growth. Forest research must begin to look more to the How and Why of things--into the physiological processes within the plant and into the ecological reactions of the plant with the physical, chemical, and biological factors of its environment. Such research provides understanding of causes and effects, and understanding in turn leads to more effective practices.

A RESEARCH PROGRAM FOR HARDWOOD FOREST MANAGEMENT

The Station has compartment and plot studies in hardwood silviculture and forest management now in progress at four of its research centers. For the most part this is empirical or applied research. These projects are yielding valuable results and will be continued. However, to put research in hardwoods on a scale more nearly consonant with the importance of the resource, a considerably expanded program is called for, as has been recommended by the Northeastern Forest Research Advisory Council. In such an expanded program the major emphasis should be placed on more

research of a basic character. The general direction and scope of such a program is indicated below.

1 Soil-site studies. This has been listed earlier as one of the neglected fields of study, and also in the review of research where two recent studies in the Station were noted. Information on site relationships is an essential foundation for effective work in planting, natural regeneration, and the silvicultural aspects of forest management. Site studies should be conducted at several of the Centers, and should eventually cover all the more important species in our region, both hardwood and softwood. Hardwood species that should be worked on include basswood, black cherry, yellow-poplar, white ash, sugar maple, oaks, white and yellow birches, and sweet gum. In the course of studies of these species or of the types in which they occur, we should also learn a good deal concerning site relationships of two less valuable but highly ubiquitous species--red maple and American beech.

2 Natural-regeneration studies. These should be concerned with ascertaining the physical and biotic factors that influence establishment of natural reproduction of the important species, and with finding ways to modify or control those factors to obtain desired reproduction.

3 Hardwood-planting studies. These should include (a) nursery studies, and (b) field planting. The latter should be concerned with essentially the same factors and objectives as in natural regeneration. The nursery studies could be mostly of an empirical nature, aimed at determining the proper levels of soil nutrients, moisture, seedling density, and other controllable variables for the production of high-quality hardwood planting stock. The Station is now committed to work along these lines, starting on sugar maple. In an expanded program, the studies should be extended to cover yellow-poplar, ash, cherry, and other species.

4 Basic physiological-ecological studies. These should also deal with the factors that influence seed germination and seedling growth, but with greater emphasis on the basic aspects and, as required, with use of more precise techniques than are implied in Nos. 2 and 3 above. We are particularly fortunate at our Beltsville Center in having access to the special facilities of the Agricultural Research Center. Investigations there can include laboratory and greenhouse studies as well as nursery and field work on the effects of such factors as light, temperature, moisture,

and nutritional levels upon germination and growth. At most of the other Centers, the investigations of necessity would be restricted to ecological field studies.

5 Wildlife relationships and control. These studies might be mostly empirical tests of control measures, or they might get into basic factors, depending upon the cooperative arrangements that may be possible, and the availability of properly trained personnel. If a wildlife technician could be permanently attached to the Station, some basic work on animal populations, nutrition, and the like would be possible.

6 Genetics. Additional work on hardwoods should be undertaken, probably at the Morris Arboretum. Attention should be devoted particularly to the birches, maples, oaks, yellow-poplar, and black cherry. We expect to continue field testing of the hybrid poplars.

7 Stand studies. These studies should be largely applied research aimed at determining optimum levels of stocking and stand structure for: (a) important forest types; and (b) different forest-management objectives. These should give us the number and size of trees for different ages, different sites, and different species mixtures that will yield the optimum continuous flow of a variety of forest products.

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